THE CONTROL OF AQUATIC VEGETATION WITH '2, 4-D'[1]

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Introduction

It is well known that aquatic plants play an important role in the economy of freshwater fisheries. During photosynthesis they liberate the oxygen required for the respiratory needs of the animal and plant life. They also afford shelter for the fry and fingerlings of fish and extract inorganic nutritive materials of biological significance from the soil, water and air. On decay, they add fertilising elements to the medium and thus increase the nutritive value of the plankton, the vital link in the fish food chain.

Some aquatic plants such as the water hyacinth (*Eichornia speciosa*), *Hydrilla verticillata, Najas graminea, Chara zeylanica, Nitella acuminata, Vallisneria spiralis*, etc., have a tendency to grow dense and cover the entire volume of water. Their thick growth causes considerable inconvenience to fishery activities, especially in the operation of nets. The wild growth of submerged and emergent plant life leads to over-population of stunted fish and reduction in the fish crop. Therefore, control of undesirable aquatic vegetation of fish ponds is necessary for the healthy development of fish life.

Three main methods—mechanical, biological and chemical—are employed at the present day in the control of aquatic vegetation (Speirs, 1948; Surber, 1949). The mechanical method consists of weeding, cutting, raking or ploughing, draining, drying or burning by manual labour, dredging and using of mechanical mowers, saws, wires and underwater scythes. This method is laborious and often provides only temporary benefit. The biological control consists of developing algal bloom or dense growth of filamentous algae by the application of fertilizers in order to 'shade out' the larger submerged aquatics (Swingle and Smith, 1939 and 1942; Surber, 1946 and 1948).

While this may increase the productivity of the water, Ganapati, Chacko and Srinivasan (1950) have observed that oxygen depletion may occur, causing fish mortality. Another biological method is the introduction of suitable species of fish which feed on aquatic weeds. The carp, *Cyprinus carpio,* is said to control submerged vegetation both by rooting it out and by increasing the turbidity of the water. In Madras, the Gourami (*Osphronemus gorami*) has been found to check to some extent the growth of weeds in irrigation wells (Ganapati, 1947). The chemical control consists of the application of a wide range of chemicals such as nigrosine, orthodichlorobenzene, copper sulphate, sodium arsenite, sodium chlorate, chloramine, etc. These chemicals have not become popular because while they appear effective for the control of plant life, they are toxic to fish life, higher animals and man.

As a result of further research in the direction of chemical control, plant growth regulating chemicals such as '2, 4-D' (2, 4-Dichlorophe-

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noxy acetic acid) have proved of immense value in the control of emergent aquatic plants (Bauman, 1947; Surber *et al.*, 1947; Cornell, 1949; Snow, 1949; Omand, 1950). It is however, believed that the practical use of this chemical compound is expensive (Walker, 1948), particularly for the control of submerged plants (Gerking, 1948; Surber, 1949).

2, 4-D is available in different forms known as sodium salts, amine salts and esters. The authors got an opportunity to test the chemical control of aquatic weeds at Madras in 1951, using 'Dicotox', an M & B product, containing the ethyl ester of 2, 4-D.

Laboratory Experiments

Laboratory experiments were first made to find the effect of 'Dicotox' on submerged plants such as *Hydrilla verticillata* and *Najas graminea*, and rooted plants such as *Vallisneria spiralis* and *Nymphaea rubra*. A layer of sand to a thickness of about two inches was spread on the bottom of four clay tubs, 3 ft. wide and 1 ft. deep. All were filled to a depth of 10 inches with water from a nearby pond. A number of vigorously growing plants of these four species were planted in each of the tubs. The roots of *Vallisneria* and *Nymphaea* were properly set in the sand. The tubs, marked A, B, C and D, were treated with 'Dicotox' at the rates of 0, 1, 2 and 3 oz. per 100 sq. ft. of surface respectively. Daily observations were recorded on the performance of the weeds. The water level in the tubs was maintained constant throughout the experiment by the addition of adequate quantity of water lost by evaporation. It was noticed that all the four varieties of plants were killed; those in tub D in 6 days, in tub C in 11 days, and in tub B in 19 days. The untreated plants in tub A were alive and in good condition throughout the conduct of the experiment. It was also observed that *Hydrilla* and *Najas* were more easily affected by 'Dicotox' than *Vallisneria* and *Nymphaea* which were rooted forms.

Effect on Fish

Experiments were carried out in order to find the effect of 'Dicotox' on fish. Three tubs, A, B and C, similar to those used in the foregoing experiment, were filled with water and plants. Two specimens each of *Labeo fimbriatus, Cirrhina reba, Barbus sarana* and *Rasbora daniconius,* were introduced into each of them, ranging in size from 1½ to 5 inches. Tub A was set aside as control and tubs B and C were treated with 'Dicotox' at the rate of 1 oz. and 2 ozs. per 100 sq. ft. respectively. The reaction of the fish and the weeds to the chemical was carefully observed. While the weeds were killed in tubs B and C at the end of 19 and 11 days respectively, the fish withstood the 'Dicotox' concentrations successfully. The observations were confirmed by a series of replicated tests.

A series of tests were planned and conducted to determine the lethal concentration of 'Dicotox' for some of the common species of fish, with a view to ascertain the safety limit for treatment with 'Dicotox'. In one test, four tubs A, B, C and D, each containing two specimens each of *Labeo fimbriatus, Cirrhina reba, Barbus sarana* and *Rasbora daniconius,* 1½ to 5 inches in length, were treated at the rates of 0, 2, 3 and 5 oz. per 100 sq. ft. of 'Dicotox'. The experi-

ment was concluded after 8 days during which time there was no mortality in any of the tubs. In another experiment, tubs A, B, C, and D, containing the same number and kind of fish as above, were treated with 0, 6, 8 and 10 oz. per 100 sq. ft. of 'Dicotox'. All the fish died in pot D on the 4th day and in tubs B and C the fish showed signs of distress after the 4th day. From these tests it is possible to assume that common carps are affected by a concentration higher than 5 oz. per 100 sq. ft.

Effects on Freshwater Life

The direct influence of 'Dicotox' on freshwater biota was also examined. Two aquaria were filled with tap water and both phyto- and zoo-plankton collected from a pond were introduced into them in sufficiently large numbers. One aquarium was set aside as control and the other was treated with 'Dicotox' at the rate of 2 ozs. per 100 sq. ft. It was noticed that the euglenoids and peridinians died on the first day and formed a scum on the surface of the latter aquarium. During the second, third and fourth days, the other phyto-planktonic organisms, such as blue-green algae, green algae and diatoms, perished. On the other hand, the zooplanktonic organisms such as rotifers, copepods and daphnids and the hydra not only survived but also multiplied in large numbers.

Field Experiments

The laboratory tests provided sufficient data on the concentrations required for eradication of four types of aquatic plants without causing harm to fish life. With a view to confirm these findings, and evolve a practical method of application of the chemical, field experiments were conducted in one of the ponds of the Chetput fish farm. The pond had a water expanse of 1,000 sq. ft. and depth of three feet. It contained plants like *Hydrilla verticillata*, *Najas graminea*, *Vallisneria spiralis* and *Nymphaea rubra*, and fish like *Catla catla* (6-10 inches), *Labeo fimbriatus* (5-8 inches), *Cirrhina reba* (4-7 inches) and *Barbus sarana* (4-6 inches). The required amount of 'Dicotox' at the rate of 2 oz. per 100 sq. ft. was dissolved in a bucketful of pond water and the resultant opalescent solution sprayed over the water surface. Most of the fish showed signs of distress the following day, and a few of them died on the third day. Observations were recorded on the physico-chemical conditions existing in the pond at the time of mortality. They were:—

Colour of water	...	green
Temperature	...	36·8C.
Turbidity	...	3·4 cms.
Dissolved Oxygen	...	17 mgm/litre
Free carbon-dioxide	...	nil
Carbonates	...	6·4 p.p.m.
Bicarbonates	...	256 p.p.m.
Chlorides	...	820 p.p.m.
pH	...	8·4
Silicates	...	12 p.p.m.
Phosphates	...	trace.

It would appear that these physico-chemical conditions were not in any way harmful to fish fauna. The day was cloudy and on the

previous day there had been some showers of rain, but these climatic factors cannot account for the mortality as no fish died in the adjacent untreated ponds that contained the same kind and size of the fish. In addition the fish had withstood the particular concentration of 'Dicotox' in the laboratory tests.

The experiment was therefore repeated in another pond of the Chetput fish farm under identical conditions. This time the required quantity of 'Dicotox' (at the rate of 2 oz. per 100 sq. ft.) was applied in three equal instalments at intervals of seven days. Not a single fish died during the 16 days of this experiment by which time all the weeds were completely killed, indicating that the required dose of 'Dicotox' calculated on the basis of area of water surface, should not be administered at once but in two or three equal doses at definite intervals. The experiment was repeated twice and the above observations were confirmed. A study of the biota of the ponds during the course of the experiments indicated an increase in the zooplanktonic organisms from the fourth day onwards.

In collaboration with Sri S. Nagaraja Rao, M.Sc., Assistant Director of Fisheries, Anantapur, the Bellary fort moat fish farm, 4 acres in extent and 8 to 15 ft. in depth, which was infested with a rank growth of *Hydrilla verticillata,* was treated with 'Dicotox' at intervals of a week at the rate of 1 gallon per acre (roughly 1 oz. per 100 sq. ft.). The weed was completely killed in three weeks and formed a thick brown scum on the water surface which was wafted to one side by the wind. The entire fish crop of the farm was unaffected.

Discussion

'Dicotox' is a self-emulsifying formation containing the ethyl ester of a growth regulating substance 2, 4-D. The principle involved in the control of weeds by 'Dicotox' consists of the application of the chemical to the leaves. It is absorbed by the leaf and translocated to the roots through the stem. Vaas (1951) has observed that 2, 4-D can kill floating types of vegetation like the water hyacinth but not submerged plants like *Hydrilla verticillata.* Our experiments have revealed that submerged plants like *Hydrilla verticillata* and *Najas graminea* are killed in about twenty days by 'Dicotox' application at the rate of 1 oz. per 100 sq. ft. Brown streaks and edges develop on the leaf surface of weeds a week after treatment and the weeds are finally killed. Rooted vegetation such as *Vallisneria spiralis* and *Nymphaea rubra* having their leaves shooting out of the water surface is also killed.

Surber (1949) has remarked that 'the phenoxy acetic compounds such as 2, 4-D and 2, 4, 5-T are still too expensive to be used as weed killers for submerged plants even though they are not toxic to fish in concentrations required to kill vegetation'. The cost of 'Dicotox' at present is Rs. 26 per gallon in a 40 gal. drum which works out to Rs. 70-4-0 per acre if applied at the rate of 1 oz. per 100 sq. ft.

King and Penfound (1946), Evans (1948), Surber (loc. cit.) and Vaas (loc. cit) have found that 2, 4-D does not have any harmful effect on freshwater fish within the concentrations used in practical applications. Our experiments with 'Dicotox' have confirmed this and fish such as *Catla catla, Labeo fimbriatus, Cirrhina reba* and *Barbus*

sarana, successfully withstood a concentration of 5 oz. per 100 sq. ft. of 'Dicotox' whereas the concentration required to kill *Hydrilla verticillata* and *Najas graminea* in about 20 days is only 1 oz. per 100 sq. ft.

King and Penfound (loc. cit.) suggested that the decaying weeds might lower the oxygen concentration in the water to a marked extent and thus might harm indirectly the fish-fauna. Vaas (loc. cit.) found, however, that no such harmful effect occurred in his experiments under tropical conditions in Indonesia. Our field experiments with 'Dicotox' confirmed that the decaying weeds did not lower the available oxygen to the fish life. Our laboratory tests showed that all the phytoplankton died and that only some of the zooplanktonic organisms were killed. When the experiments were repeated under natural conditions in the ponds of the Chetput fish farm, it was observed that there was an increase in the phytoplankton from the second day onwards and an increase in the zooplankton from the fourth day onwards. Evidently the decaying weeds had encouraged the development of plankton.

Conclusions

From the series of experiments it is concluded that (1) 'Dicotox' is able to eradicate submerged weeds like *Hydrilla verticillata* and *Najas graminea* and the rooted plants such as *Vallisneria spiralis* and *Nymphaea rubra*; (2) a dosage of 1 oz. of 'Dicotox' per 100 sq. ft. kills these four kinds of aquatic plants in about 20 days, or a dosage of 2 ozs. per 100 sq. ft. administered in three equal instalments at intervals of 7 days, kills them in about 16 days; (3) neither of these 'Dicotox' dosages is harmful either directly or indirectly to freshwater fish such as *Catla catla*, *Labeo fimbriatus*, *Cirrhina reba* and *Barbus sarana*; but there is a phenomenal increase in the density of freshwater biota of a pond treated with 'Dicotox' from the fourth day; (4) the cost of treatment works out to Rs. 70-4-0 per acre.

Summary

The role of aquatic vegetation in the economy of pond life and the various methods that are in vogue for the control of aquatic plants are recounted. From a number of field experiments it is concluded that a concentration of 1 oz. per 100 sq. ft. of 'Dicotox' costing Rs. 70-4-0 per acre is capable of killing submerged plants such as *Hydrilla* and *Najas* and rooted plants like *Vallisneria* and *Nymphaea* in about twenty days. 'Dicotox' was also tested for its harmlessness to fish and freshwater biota.

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[The Editor of our Botanical Section who needed clarification on a certain point wrote to the author as under:—

'In the paper you speak of so many ounces per square unit of surface. On the other hand from the context "Dicotox" is not spoken of as an oily substance that acts by spreading on the surface, but going into the water. Surely in this case the *volume* of water is more important than its *surface*. Is this correct? We have tried "Dicotox" in Bombay and it seems to form a perfect solution in water.'

Mr. Chacko offers the following explanation:—

'"Dicotox" is a self-emulsifying oil which is absorbed by the leaf and translocated to the stem and finally to the roots. As such, it is enough if this oily weedicide comes into contact with a portion and not the entire plant. The plants *Hydrilla verticillata, Najas graminea, Vallisneria spiralis* and *Nymphaea rubra* have their leaves shooting towards the water surface, and are easily killed. So we have spoken in terms of surface area. Our field experiments at Madras and at Bellary in waters of varying depths have confirmed our view.'—EDS.]